RAPID LATENSIFICATION OF PRINTOUT MATERIAL

Original Filed Sept. 14, 1959

INVENTORS

RICHARD P. BROWN
JOHN H. JACOBS

Christie Parker Hale
ATTORNEYS
RAPID LATENSIFICATION OF PRINTOUT MATERIAL

Richard P. Brown, Monrovia, and John H. Jacobs, Alhambra, Calif., assignors to Consolidated Electrodynamics Corporation, Pasadena, Calif., a corporation of California


13 Claims. (Cl. 96—27)

The present invention relates to the field of recording on printout material, and, more specifically, relates to the rapid latensification of such material without fogging. This application is a continuation of our co-pending application Serial No. 839,617, filed September 14, 1959, and now abandoned.

Materials which carry a photosensitive emulsion on one surface, such that an image recorded on the emulsion may be rendered visible by appropriate processing, are well-known. Such materials may have a variety of emulsion compositions. However, the basic constituents of such emulsions are a silver halide compound, usually in a matrix of gelatin. The silver halide compound is present in the form of crystals, usually triangular or hexagonal in configuration. The process by which an image is recorded by means of these silver halide crystals is not well understood, even though this process, which is the basic process in photography, has been utilized for many years.

It has been found that rapid latensification without fogging of printout material can be accomplished by subjecting the exposed printout material emulsion to heat and subsequently exposing the printout material emulsion to electromagnetic radiations within a selected band of wave lengths. This statement, briefly, describes the present invention, and the following theoretical discussion is made in an effort to explain the mechanism of operation of the invention as it is presently understood. The recording process consists of a building up of specks of silver atoms about certain loci on the silver halide crystal as a result of exposure of the crystal to electromagnetic radiations. The band of electromagnetic radiation wave lengths which are operable to initiate such a build-up is hereinafter referred to as the original recording sensitivity of the material.

The following theoretical premises are made in order to provide a basic theory upon which to base an explanation of the invention. A site which acts as the locus of a build-up of silver on the silver halide crystal apparently consists of a silver ion at a discontinuity in the crystal lattice. This ion adsorbs a silver atom to become a latent pre-image speck. Th speck is then built up by additional silver atoms to form a latent image speck. The latent pre-image speck has a comparatively short lifetime, whereas the latent image speck exhibits stable existence.

The lifetime of the latent pre-image speck is dependent upon the temperature at which the emulsion is developed. Elevation of the emulsion temperature decreases the lifetime of the latent pre-image speck. Unless the latent pre-image speck adsorbs an additional silver atom, thereby becoming a latent sub-image speck, the latent pre-image speck dissociates into a silver atom and a silver ion. The latent sub-image speck, consisting of two silver atoms adsorbed by a silver ion, is heat-stable; that is, the elevation of the temperature of the emulsion does not cause the latent sub-image speck to dissociate into silver atoms and a silver ion. However, these latent sub-image specks are not developable as such. Rather, the silver atom content of the speck must increase in number so that the speck reaches a developable size, i.e., becomes a latent image speck. Latent image specks, like latent sub-image specks, are heat-stable.

For a given radiation wave length within the original recording sensitivity of the material, the number of such latent image specks which result upon exposure to the radiation is roughly proportional to the product of the intensity and duration of the exposure. This relationship is known as the reciprocity law. However, for a particular material, this process of producing latent image specks has a maximum efficiency at a certain intensity of radiation. At intensity levels either greater or less than this intensity, the process is less efficient and results in a deviation from the reciprocity law which is known as reciprocity law failure. At recording exposures which utilize an exposure in the high-intensity reciprocity failure region, apparently a large number of latent sub-image specks results on the silver halide crystals during the recording exposure, rather than latent image specks.

So long as the silver halide crystals remain in existence as crystals, the image is said to be a latent image. The latent image is developed by the reduction of those silver halide crystals which contain latent image specks to metallic silver (chemical development); or the deposition on those crystals containing latent image specks of silver not directly derived from the silver halide crystal, which deposition is dependent upon the number of latent image specks on the silver halide crystal (physical development). In addition, the recording radiations may themselves actually decompose the silver halide crystal so as to produce a metallic silver deposit at the latent image speck site (photolysis).

Recording materials are well-known which make use of various combinations of chemical and physical development and photolysis in order to make the record itself visible soon after the actual act of recording. Recording radiations in the high-intensity reciprocity failure region are utilized with materials of this type in high speed oscillography. These materials are comparatively insensitive to radiations within the original recording sensitivity of the material which are of low intensity, as are found in ambient lighting, for example. The recorded image is itself made visible by the action of material already in the emulsion which is usually accelerated by impregnation of the material to electromagnetic radiations. These materials do not require the subsequent application of a developing solution to render the image visible. Such recording materials are known as printout materials or printout papers.

Some early efforts relating to the use of printout materials to produce a continuous visible record of information are illustrated in the following patents:

German Patent No. 872,155
German Patent No. 880,496
U.S. Patent No. 2,580,427

The process by which the recorded image is made visible on printout materials by the exposure of the material to electromagnetic radiations is referred to, hereinafter, as latensification, although the actual process so designated embraces combinations of chemical and physical development of the latent image by materials already in the emulsion and photolysis of the silver halide crystals containing latent image specks. The word latensification, as used hereinafter, is therefore not limited to the build-up of silver atoms at latent pre-image specks to form latent image specks on silver halide crystals.

The term access time is used to indicate the time interval between the exposure of a photosensitive material to an electromagnetic recording radiation and the presentation of a visible record for observation. Conventionally, latensification of printout materials is carried out at normal room lighting intensities. The latensification of printout materials by this conventional method has resulted in access times in the range of magnitude of thirty or more seconds for latensification with satisfactory distinctness of the record.
It is often desirable and even necessary to record information at printout material transport speeds in the order of magnitude of several inches per second so as to provide a useful record. In order to latensify the image recorded at such speeds, continuous exposure of the material to latensifying radiations for the thirty-second period is still necessary in conventional practice. Thus, it is readily apparent that the amount of printout material which must be exposed to light over any prolonged period at such speeds is so great as to have made impractical the use of such speeds heretofore.

Attempts to increase the rate of latensification and thus reduce the access time of printout materials by utilizing higher latensifying radiation intensities have heretofore resulted in fogging of the material. Fogging of the printout material is caused by the exposure of the material to high-intensity radiations within the original recording sensitivity of the material and the resulting formation of randomly distributed latent image specks. Fogging causes a lack of contrast to exist between the background of the printout material and the latent image corresponding to the recorded intelligence. Thus, the rate of latensification of printout materials heretofore could not satisfactorily be increased by subjecting printout materials to latensifying radiations of higher intensity to give an access time of appreciably less than thirty seconds without fogging the source.

According to the present invention, the rapid latensification without fogging of printout materials to give access times of less than one second is accomplished by the latensification of the printout material while its original recording sensitivity is inactive. Inactivation of the original recording sensitivity of the printout material is accomplished by elevating the temperature of the printout material prior to its exposure to the latensifying radiations.

The mechanism by which the practice of the present invention precludes fogging of the printout material during latensification appears to be related to the theoretical premise that the latent pre-image specks have a lifetime which is temperature-dependent, whereas, the latent sub-image specks and latent image specks are heat-stable. It appears that dissociation of the silver atom and silver ion forming the latent pre-image speck occurs at a much faster rate when heated, so that new latent pre-image specks formed during latensification dissociate before adsorbing the additional silver atoms and ions required to constitute a stable speck for the formation of a latent image. The elevation of the emulsion temperature thus may inhibit the formation of latent sub-image specks from latent pre-image specks formed as a result of exposure of the printout material to the latensifying radiations, or it may actually prevent the formation of latent pre-image specks. In either event, the result is to inactivate the original recording sensitivity of the printout material. However, as was previously postulated, latent sub-image specks already existing as a result of the recording exposure are heat-stable at the temperatures contemplated by the invention. Exposure to the latensifying radiations causes these latent sub-image specks to adsorb additional silver atoms and become latent image specks. As the latent image specks are also heat-stable, the process by which the latent image specks are latensified to form a visible image is not inhibited by heating the emulsion.

For certain printout materials, to preclude fogging in the practice of the invention, it is necessary to expose the printout material to the latensifying radiations during the period when the temperature of the emulsion of the material is elevated. For other materials, it will suffice to elevate the temperature once, the temperature thereafter at which latensification occurs not normally being significant for the practice of this invention. It is not understood why the inactivation of the original recording sensitivity is permanent in one instance and temporary in the other.

The invention may be more readily understood by reference to the accompanying drawings in which:

FIGURE 1 is a second side view of the recording and rapid latensification of printout material according to the invention; and

FIGURE 2 is a graphical representation of printout material sensitivity to electromagnetic radiations.

With reference to FIG. 1, a recording oscillograph 11 has an outer casing 12. A galvanometer mirror 13, connected to a galvanometer (not shown), reflects light directed therefrom from a light source 14. The light source 14 may be, for example, a conventional mercury vapor point source commonly used in recording oscillographs. The light reflected from the galvanometer mirror 13 passes through an aperture 15 in an inner dividing wall 16 of the oscillograph 11. Printout paper 17 contained in a roll 18 passes around a recording roller 19 positioned adjacent the aperture 15 so that the light reflected through the aperture 15 falls upon the printout paper 17. The printout paper 17 then passes around an idler roller 20 and onto a platen 21. The platen 21 contains a means (not shown) operable to heat the platen 21 to a temperature which may be, for example, two hundred and fifty degrees Fahrenheit. This heat is transferred to the printout paper 17 as it passes over the platen 21 prior to exposure of the printout paper 17 to latensifying radiations from a latensifying radiation source 22.

The latensifying radiation source 22 produces radiations which fall upon the printout paper 17 as it passes along the platen 21. After leaving the platen 21, the printout paper 17 is carried between a drive roller 24 and a second idler roller 25. These two rollers 24 and 25 provide the traction by means of which the printout paper 17 is unrolled from the roller 58 and passed along the path just described. Upon passing through the rollers 24 and 25, the latensified printout paper 17 issues from an aperture 27 in the oscillograph outer case 12 and is available for viewing, editing, and, if required, permanent fixing of the image.

It has been found that various types of printout materials exhibit latensification bands of differing widths. For example, the printout paper of one manufacturer exhibits a latensification band which extends from 2300 Angstrom units to 4700 Angstrom units, as is illustrated by solid line 20 and dotted line 31 in FIG. 2. The latensification band of the printout material of a second manufacturer extends from 2500 Angstrom units to 5700 Angstrom units, as is illustrated by line 30 and dotted line 32 in FIG. 2.

In these printout materials, it has been found that there is a band of original recording sensitivity which falls generally between 3500 and 4300 Angstrom units. The exact limits of the band are determined by the particular material. The latent sub-image specks, at which points the latent image subsequently forms, result from the exposure of the particular portions of the printout material to electromagnetic radiations within the range of the original recording sensitivity of the material in a configuration corresponding to the intelligence to be recorded.

Radiations beyond the upper limit of the latensification band, that is, the maximum value in Angstrom units of radiations which exhibit the characteristic of rapid latensification, have been found to exhibit a desensitization effect when projected upon images recorded on printout materials prior to or during latensification. This desensitization effect apparently is a manifestation of the well-known Herschel effect, and is illustrated by dotted lines 33 and 34, for the papers of the first and second manufacturers referred to above, respectively, and solid line 35 in FIG. 2. The Herschel effect consists of the destruction of a latent image formed by electromagnetic radiations of a certain wave length by subjecting the latent image to radiations of an appreciably longer wave length. Although the Herschel effect is not particularly strong in most printout materials, the upper limit of the radia-
tions useful for latensification apparently is defined by the radiation wave length at which the effect commences to be manifested. However, because latensification according to the invention is a high-intensity process and the Herschel effect is normally a low-intensity effect, the upper limit of latensifying radiations is not well-defined.

In practicing the invention, for the printout materials currently available, heating of the platen to a temperature in the order of magnitude of two hundred and fifty degrees Fahrenheit has the effect of inactivating the original recording sensitivity of the printout material. Of course, practice of the invention is not limited to the use of heated platens. A heated roller, or any other appropriate heat transfer means, can be used.

In certain types of printout papers, upon heating, the inactivation of the original recording sensitivity is permanent, whereas, in others, the inactivation process has been found to be reversible so that inactivation is only temporary. In the practice of the invention, after the elevation of the temperature of the printout material, the material is exposed to the latensifying electromagnetic radiations and latensification occurs. In the type of printout material in which the inactivation of the original recording sensitivity is permanent, the printout material may be allowed to cool prior to its exposure to the latensifying radiations. However, such cooling normally does not occur in use of the invention, allowing the printout material to cool is not consistent with the requirement of a rapid access time. In the type of printout material in which the inactivation of the original recording sensitivity only exists so long as the temperature of the material remains elevated, it is, of course, necessary to expose the material to the latensifying radiations while the temperature is so elevated, in order to avoid background fogging while practicing rapid latensification according to this invention.

Inasmuch as the rapid latensification of printout material is a novel process, data on the various printout materials with regard to the practice of this invention are not available. Therefore, it is necessary, with respect to the various types of printout materials, to experimentally determine the original recording sensitivity range and the latensification range of the material. The temperature required for inactivation of the original recording sensitivity is permanent, and the heating of the material prior to latensification results in a permanent or only temporary inactivation of the original recording sensitivity, are determined experimentally.

The determination of the original recording sensitivity and latensification ranges of a particular printout material is accomplished by first recording intelligence on a strip of the printout material. Latensification is preferably made utilizing a white light source, so as to subject the printout material to radiations having a broad range of wave lengths. The spectrum of the anticipated latensification range of the printout material is then spread out according to wave length on the recorded material by means of a spectograph. The width of the latensification band of the printout material is apparent from the printout material as corresponding to the wave length band over which the recorded information has been latensified. The region of original recording sensitivity of the material then corresponds to that portion which exhibits both latensification of the recorded intelligence and background fogging. In extreme cases, the fogging may obscure the image. In the region of the upper limit of the latensification band, the latensification effect is less pronounced, the Herschel effect in this region, latensification of the recorded image may not occur upon subsequent exposure of this portion of the material to radiations within the latensification band.

Having determined the lower limit for latensification radiations, and the upper limit of the latensification radiations, i.e., the wave length at which the Herschel effect becomes significant, an appropriate latensification radiation source is selected by comparing radiation spectrums for various available sources of radiation with the radiation spectrum required for rapid latensification of the printout material according to the invention. After determining the latensification band of the printout material, and providing a suitable latensification radiation source, the temperature to which the material must be elevated in order to preclude fogging, by inactivating the original recording sensitivity of the material, is determined by trial and error method. A trial and error method is preferable in order to take into account the heat transfer characteristic of the particular heat transfer means utilized to elevate the temperature of the printout material and the transport rate of the material. If it is further desired to determine whether the original recording sensitivity of the material remains inactivated after having its temperature elevated, a portion of the material is allowed to cool prior to latensification. If latensification of the cooled portion is accompanied by background fogging, the inactivation of the original recording sensitivity of the material upon heating is temporary rather than permanent.

The source chosen for the latensification radiations may emit significant amounts of radiation beyond the upper limit of the latensification band. Whether or not these radiations are such as to degrade the quality of the latensified image must be determined experimentally for the particular radiations and printout material. The latensification process usually becomes less efficient in the region of the upper limit of the latensification band. This region may or may not overlap the region in which the Herschel effect normally becomes significant for the particular printout material. Thus, in the practice of the invention, the upper limit of the latensification band is defined by that region beyond which, for the particular printout material and latensification spectrum utilized, additional radiations of longer wave length are not significantly useful to produce latensification of the recorded image. However, the use of a latensifying radiation source emitting, in addition to radiations within the latensification band of the material, such additional radiations of longer wave length, constitutes practice of the invention whether or not such longer wave length radiations actually produce any latensification of the recorded image.

We claim:
1. A process for the rapid latensification of images on latensifiable silver halide printout material without fogging the material, consisting of recording a latent image on printout material by means of electromagnetic radiations within the range of wave lengths, heating the material prior to latensification results in a permanent or only temporary inactivation of the original recording sensitivity, and subsequently exposing the images so recorded on the printout material to latensifying electromagnetic radiations while the original recording sensitivity of the printout material is inactive.
2. A process for the rapid latensification of images on latensifiable silver halide printout material without fogging the material, consisting of recording a latent image on the printout material by means of electromagnetic radiations within the range of wave lengths, heating the material prior to latensification results in a permanent or only temporary inactivation of the original recording sensitivity, and subsequently exposing the images so recorded on the printout material to latensifying electromagnetic radiations while the original recording sensitivity of the printout material is inactive.
3. A process for inducing the rapid transition to a visible form of an invisible image on a latensifiable silver halide printout material by means of recording an invisible latent image on the printout emulsion elevating the temperature of the printout emulsion by means of a heat source at a temperature in excess of two-hundred degrees Fahrenheit to substantially inactivate the recording sensitivity of the printout emulsion without destroying the invisible image and, while the sensitivity of the printout emulsion is so inactivated, exposing the emulsion con-
taining the invisible image to electromagnetic radiations of the wave lengths used to record said image to produce a rapid transition of the recorded image to visibility without appreciable fogging.

4. A process as described in claim 3 in which the temperature of the printout emulsion is at a temperature which inactivates the recording sensitivity during the exposure of the emulsion to the electromagnetic radiations producing the transition of the image to visibility.

5. A process for inducing the rapid transition of invisible images on a latensifiable silver halide printout material to visibility without fogging the material consisting of recording an invisible latent image on the printout material by means of electromagnetic radiations within the range of spectrum capable of forming a latent image on the printout material, thereafter heating the printout material by means of a source of heat at a temperature of about two-hundred-fifty degrees Fahrenheit to substantially inactivate the recording sensitivity of the printout material to further electromagnetic radiations within said spectrum, and, while the sensitivity of the printout material to radiations within said spectrum is inactivated, exposing the images recorded on the paper to further electromagnetic radiations in a range which includes at least a portion of the aforesaid spectrum to produce a rapid transition of the recorded invisible image to visibility.

6. A process for inducing the rapid transition of an invisible image on a latensifiable silver halide printout paper to visible form without fogging the paper consisting of recording, for a period of time sufficient to form a latent image on the paper but insufficient to produce an immediately visible image thereon, an invisible image on the printout paper by means of electromagnetic radiations within the range of spectrum capable of forming a latent image on the printout material, thereafter bringing the printout paper into contact with a heat source at a temperature of about two-hundred fifty degrees Fahrenheit to substantially inactivate the sensitivity of the printout material to further electromagnetic radiations within said range, and, while the sensitivity of the printout paper to electromagnetic radiations within said range is inactivated, exposing the paper to further electromagnetic radiations including radiations within said range to produce a rapid transition of the latent image to visibility.

7. The process as described in claim 6 in which the heat source is a heated platen over which the printout paper passes so that the paper backing separates the paper emulsion from the heated platen.

8. A method of oscillography utilizing an oscillograph recording paper of the latensifiable silver halide printout emulsion type having a known range of original recording sensitivity and a known latentification band which is broader than and includes the range of original recording sensitivity, comprising the sequentially performed steps of: (a) invisibly recording information in the form of a latent image on the emulsion by (1) moving the emulsion past an information recording location and (2) exposing the moving emulsion as it passes the information recording location to electromagnetic recording radiations of wavelengths within the range of the original recording sensitivity; (b) inactivating the original recording sensitivity of the emulsion by (1) heating the mov-

9. The method of claim 8 in which the latensifying radiations include radiations within the range of between 2500 Angstrom units and 3700 Angstrom units.

10. The method of claim 9 in which the recording radiations include radiations of wave lengths between 3500 Angstrom units and 4300 Angstrom units.

11. The method of claim 10 in which the original recording sensitivity is inactivated by passing the recording paper over a platen which is heated to a temperature of not in excess of about two-hundred-and-fifty degrees Fahrenheit.

12. A process for rapidly producing an oscillographic recording comprising the sequentially performed steps of (a) recording information in the form of a latent image by means of reflecting electromagnetic radiations including wave lengths within the range from 3500 Angstrom units to 4200 Angstrom units on a moving oscillographic recording paper emulsion of the latensifiable silver halide printout type from a galvanometer mirror, (b) inactivating the emulsion, with respect to recording information by exposure to said electromagnetic radiations, by heating the moving emulsion to a temperature of not in excess of about two-hundred-and-fifty degrees Fahrenheit, and (c) latensifying the recorded information by exposing the moving emulsion to electromagnetic radiations including wave lengths within the range of from 2500 Angstrom units to 5700 Angstrom units.

13. A process for continuously recording on a silver halide latensifiable printout recording material which comprises drawing the material past a point of primary exposure while exposing it to a source of electromagnetic radiations within the spectral range to which the material is photosensitive and at an intensity and for a period of time sufficient to produce thereon as it passes the point of primary exposure a latent image to be recorded, thereafter drawing the printout material past a heat source to elevate the printout material temperature to inactivate the original recording sensitivity of the recording material so that it may be subject to higher light intensities without formation of a latent image, and thereafter exposing the material to a second source of latensifying electromagnetic radiations at an intensity and for a period sufficient to produce a latent image if the material had not been heated and while the original recording sensitivity is inactive whereby the latent image produced by the primary exposure is rapidly intensified to visibility without fogging the material.

References Cited in the file of this patent

UNITED STATES PATENTS

2,709,134 Jacobs  May 24, 1955
3,107,138 Le Massena  Oct. 15, 1963